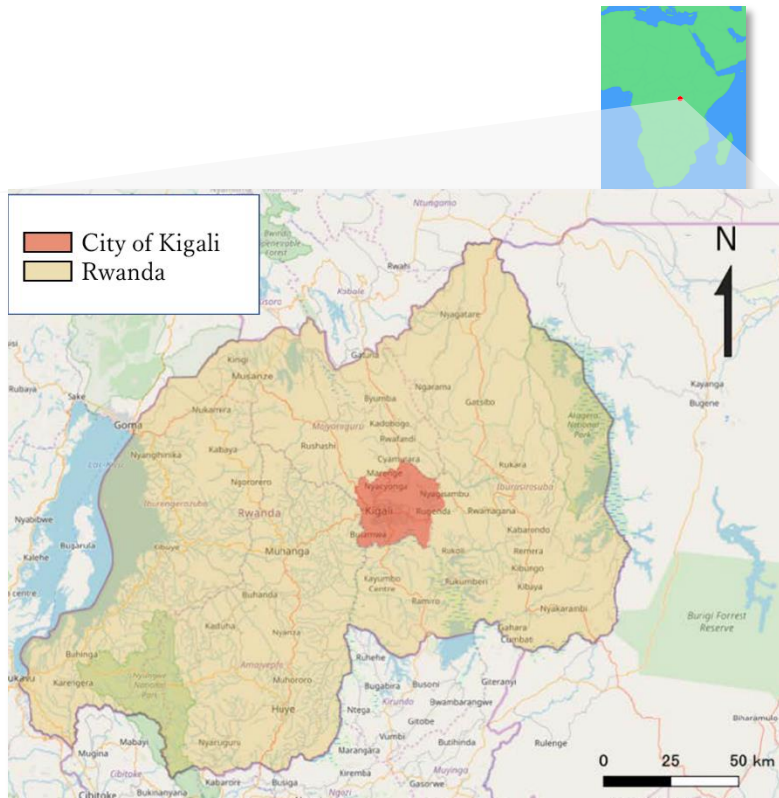


The Project for Water Supply Master Plan for City of Kigali

November 2021



1. Background of the Study

City of Kigali (CoK), the national capital, and its adjacent 7 sectors (the Study Area) are undergoing rapid development. The Fifth Integrated Household Living Conditions Survey (EICV5, 2016/2017) stated the water supply coverage in the City of Kigali is around 87%. The most significant challenge is to meet the growing water demand in the Study Area and to improve the quality of the water supply services to a satisfactory level. Water Supply and Sanitation Corporation (WASAC) is responsible for providing water and sanitation services in Rwanda. WASAC operates three primary WTPs (Water Treatment Plant) with more than 4,000 km of transmission and distribution pipelines in the Study Area. The numerous factors, including the existing geographical terrain/ features and complicated distribution systems resulted in the difficulty of

expansion of the existing facilities.



Photo: Long Queue at Public Tap

The hilly terrain in the Study Area, which is generally termed as "A thousand hills," has caused significant elevation differences in the distribution areas.

The existing facilities are expanded incrementally without a comprehensive water supply plan and design criteria to catch up with the urban sprawl. The

complicated and uncontrolled distribution systems cause significant issues such as high energy cost and high rate of Non-Revenue Water (NRW) which is the produced water that is unbilled such as leaked water.



Photo: Water Leakage

Therefore, the comprehensive Masterplan is necessary to ensure an effective and efficient high quality water supply service over a long-term perspective considering the following aspects:

- The current distribution system lacks proper zoning arrangement according to the difference of elevation, which makes it WASAC difficult to manage water distribution pressure adequately.
- The operation of some water reservoirs is unstable, and water cannot reach certain areas within the Study Area.
- The current water supply facilities have complicated networks that cause difficulty in operation and maintenance.
- There is also a concern that the Study Area may face a lack of water source due to the rapid increase in water demand.

2. Approach

2.1. Objective

The objective of the Kigali Water Supply Master Plan (M/P Report) is to provide WASAC with a blueprint of the future water supply system as well as steps to be implemented by 2050.

2.2. Organization of the M/P Report

The M/P Report consists of the Master Scenario until 2050 and the 15-Year Investment Plan. Based on the M/P Report, Feasibility Studies (F/S) on the priority projects will be conducted. In addition, technology transfer to the counterpart staff from WASAC is also being pursued during the course of preparation of the M/P Report and F/S.

2.3. Study Area

The Study Area covers the City of Kigali and its seven adjacent sectors, Shyorongi, Runda, Rugarika, Ntarama, Muyumbu, Gahengeri, and Nyakaliro (**Figure 1**).

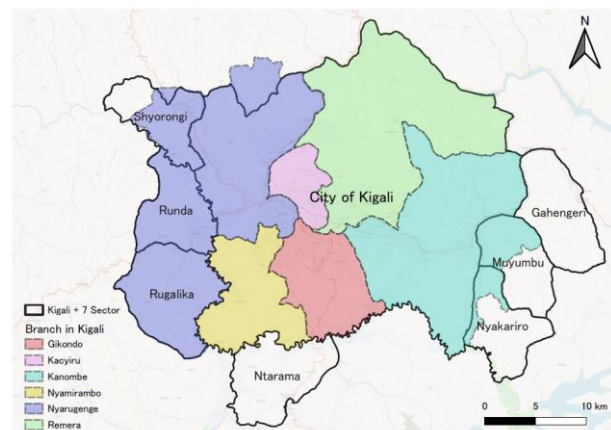


Figure 1 Study Area

2.4. Key Considerations in the M/P Report

(1) Response to Rapid Population Increase

The City of Kigali Masterplan adopted the city's actual development trends. According to that, the population of the CoK would increase rapidly from around 1.1 million in 2012 to 3.8 million in 2050 due to the large migration from rural areas. "Rationing Program (planned intermittent water supply)" is being implemented continuously at certain areas in the Study Area due to a shortage of available water. The most crucial challenge is to resolve the existing severe water shortages. It is required to set up monitoring indicators (KPIs) for the intermittent water supply and progressively achieve 24/7 water supply to anywhere in

the Study Area. Accordingly, we proposed to implement the monitoring based on the GIS Mapping as presented in **Figure 2**.

(2) Relevant and Governing Plans and Studies

The relevant and governing plans/studies were reviewed to maintain consistency with the previous studies.

Vision 2050, which defines national development goals, states that it aims to provide all Rwandan citizens with a high standard of living, including stable and sustainable individual water supply and sanitation services by 2050. Accordingly, the M/P aims to provide 100% piped water supply by 2050.

(3) Pressure Control and NRW Reduction

High electricity cost for water transmission and distribution is unavoidable because of its hilly terrain and availability of water sources located at the lower elevations. Two major approaches will reduce energy consumption: NRW reduction and appropriation of the water transmission and distribution system. Long-term planning approaches were proposed in the M/P. The introduction of the distribution block system would help

avoid the transmission routes consuming excessive energy and would help to maintain pressure within an appropriate range (**Figure 3**).

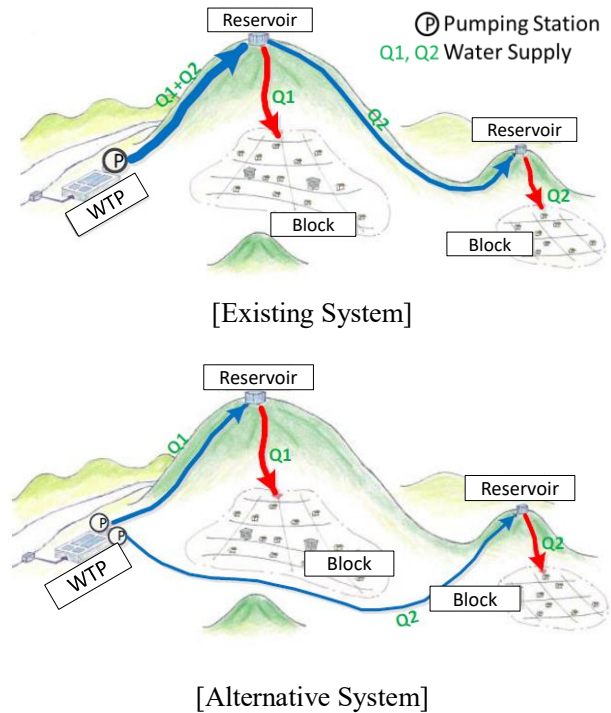


Figure 3 Concept of Distribution Block System

(4) Financial and Organizational Consideration

WASAC faces a severe financial crunch due to its high

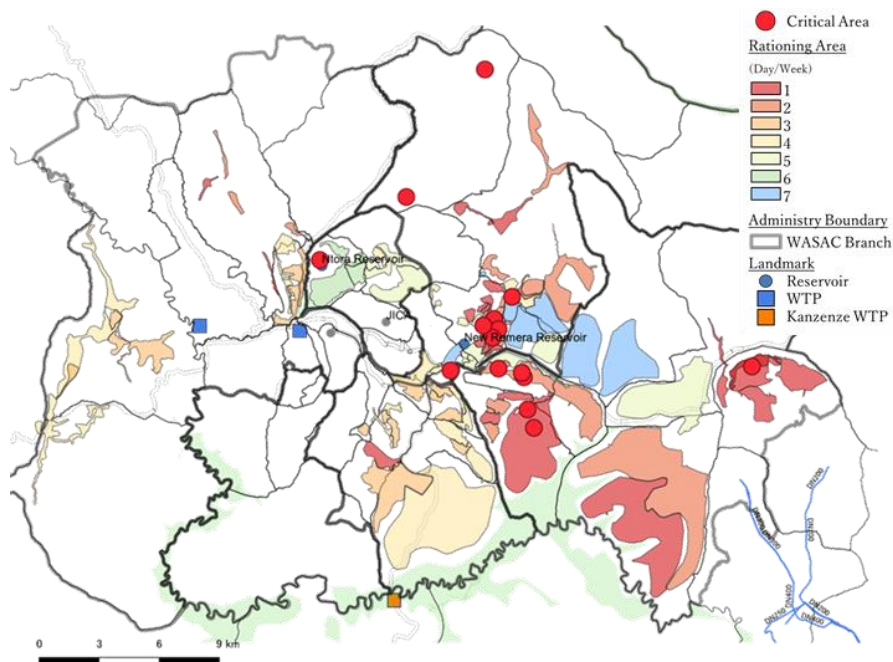


Figure 2 Rationing Program and the severe water shortage area

operational cost, mainly caused by the high energy cost and absence of periodic tariff adjustment. Inadequate revision of the water tariff may lead to deterioration of their finance.

(5) Improvement of Water Supply System

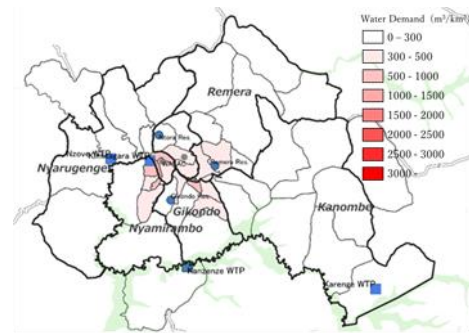
WASAC does not have a system to eliminate inferior contractors as well as poor quality material in service connection works. Additionally, pipes are installed with poor workmanship. The laying location and depth of water supply pipes are also not always appropriate, causing water leakage. The M/P emphasized the importance of renewing low-quality water supply pipes. In cooperation with the JICA NRW project, the project team created the technical standard for water supply pipes.

3. Outcomes

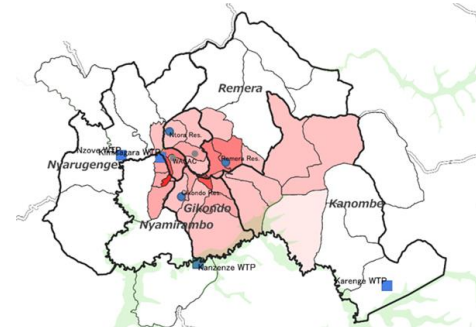
3.1. Master Plan

(1) Water Demand Projection

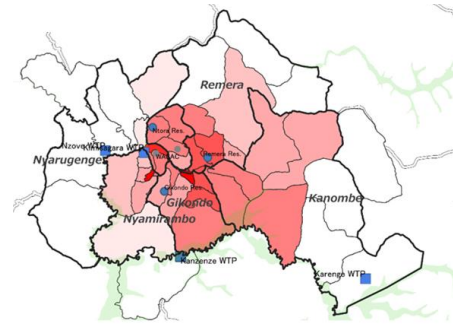
Current and future water demands are estimated considering several factors, including population, land use, timing of development, per capita consumption, service level, water needs, NRW ratio, seasonal peak factor, type of water use, and socio-economic conditions prevailing in the target area. As shown in **Figure 4**, the trend of water demand growth in the City of Kigali would be moving towards the eastern and southern parts of the city.



(2019) High water demand in the city center



(2025) Expansion of water demand



(2050) Expansion of water demand towards East

Figure 4 Trend of Water Demand Growth

(2) Water Supply Vision towards 2050

The M/P Report needs a coherent and persistent vision for its execution since the way towards 2050 is a long journey, focusing not only on increasing the production capacity but also on improving the efficiency of water supply systems through stable water supply systems and reliable and sustainable management.

WASAC needs a progressive approach to achieve universal access to safely managed drinking water services (**Figure 5**).

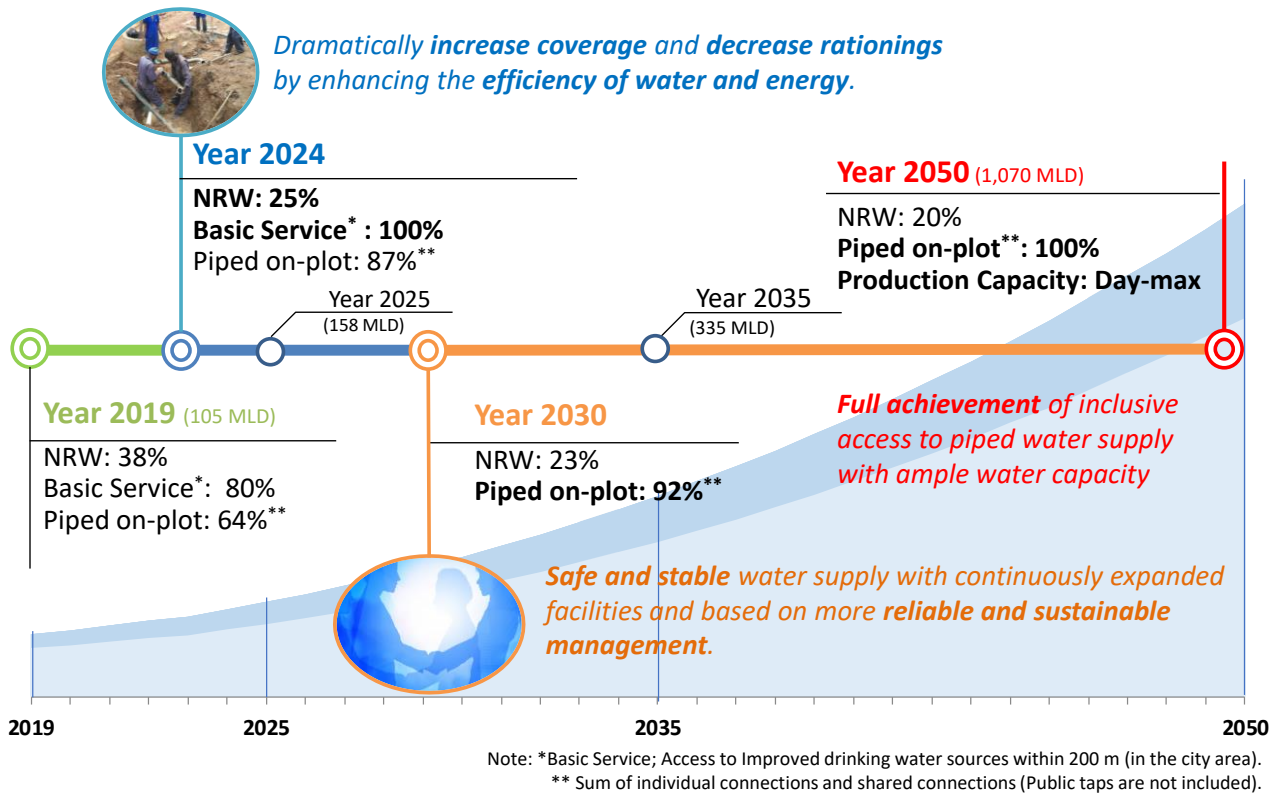


Figure 5 Water Supply Vision 2050

The visions for the benchmark years are as follows.

- 2025: Dramatically increase coverage and decrease rationings by enhancing the efficiency of water and energy.
- 2035: Safe and stable water supply with continuously expanding facilities and based on more reliable and sustainable management.
- 2050: Fully achieve inclusive access to piped water supply with ample water capacity.

(3) The Master Scenario towards 2050

The Master Scenario was selected by the Joint Coordinating Committee (JCC) in July 2020. Various options were considered while selecting the master scenario having clear evaluation criteria, namely stability, flexibility, resiliency, efficiency, and life cycle cost. The principles for setting the water supply regions are as follows.

- a) Maximum utilization of existing facilities.

- b) Consideration of existing topography.
- c) Flexibility: Setting "Mixed Area" from multiple water sources.

For the years from 2019 to 2050, the daily average water demand is adopted as the basis of the Master Scenario in order to develop a realistic and feasible plan and to achieve the demand progressively. For the year 2050, the daily maximum is adopted for completely satisfying the water demands (**Figure 6**).

(4) The 15-Year Investment Plan

The 15-Year Investment Plan (15-YIP) is the investment plan to achieve the Master Scenario. Economic evaluation is carried out for the projects proposed in the plan based on the economic costs and benefits. In conclusion, the projects are found to be feasible in terms of technical aspect, economical aspect and environmental and social consideration.

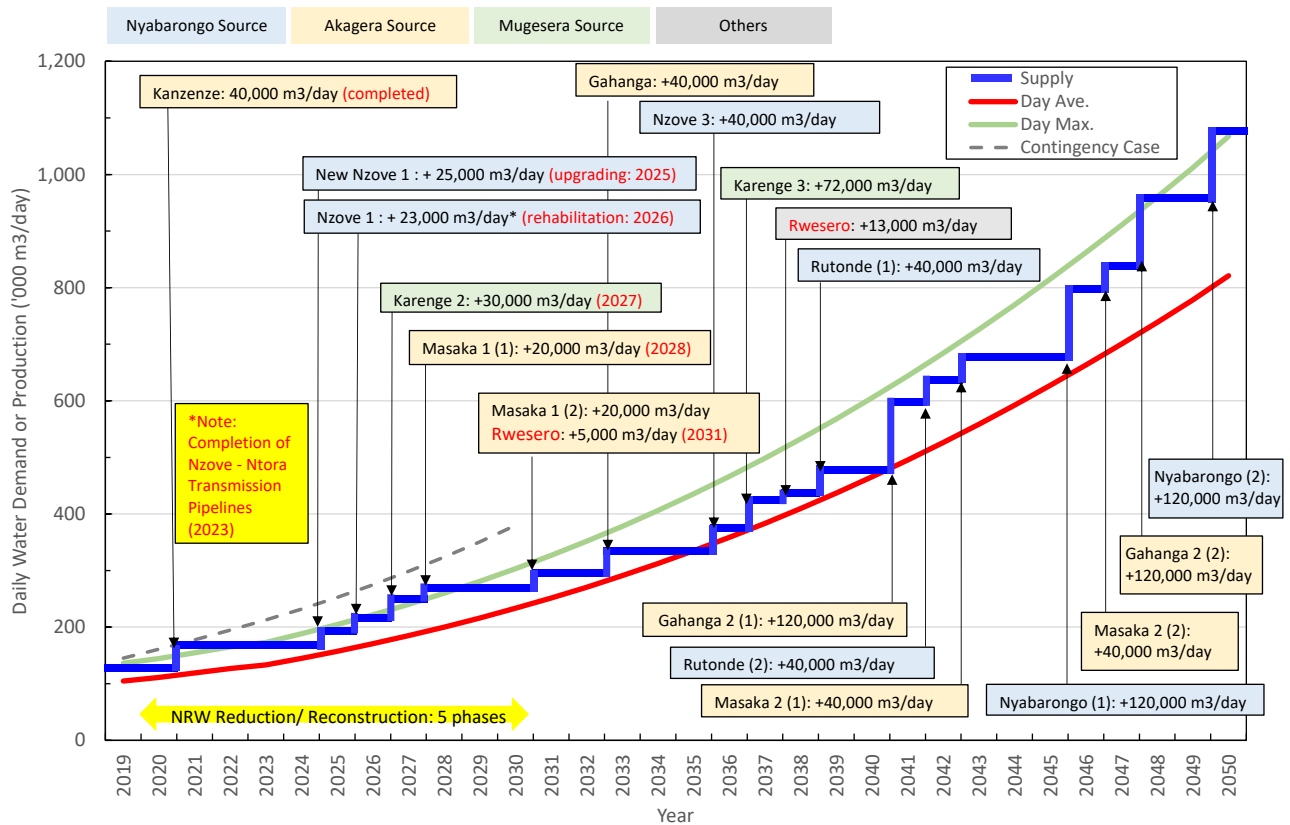


Figure 6 Master Scenario: Demand-Supply Balance and Road Map

(5) Significance of NRW Improvement

High NRW, with nearly 40%, makes it difficult for WASAC to maintain a stable water supply. It is one of the main factors that force WASAC to provide intermittent water supply for some residents. We give priority to the re-organization of the existing water supply system in order to reduce NRW under the 15-Year Investment Plan, that is, the early stage of the M/P implementation. Reconstruction of an entire distribution system in the Study Area will take a long time. Therefore, we have proposed a step-by-step approach to reduce NRW by dividing the entire project into five phases considering its large scale.

(6) Financial and Organizational Aspects

It is difficult to formulate and implement the Kigali Water Supply M/P without the formal involvement and coordination with the Water & Sanitation Development, the SPIU, and the Corporate Planning & Strategy

Division of the head office, in addition to the UWSSD. However, under the present scenario, there is a lack of organized function to work together and to develop strategies for commencement/maintenance of the long-term investment projects. Therefore, we propose to formulate One Strategic Team with a function to identify cross-organizational issues and examine measure to solve issues and develop strategies for commencement/implementation of the long-term investment projects.

(7) Private Fund Utilization

Private fund utilization should be considered as international partners. Issues and lessons learned referring to previous PPP projects, including the Kigali Bulk Water Supply Project are summarized during the Study to achieve a sustainable water supply system.

(8) Donor Coordination Mechanism

Since the source of investment will often be an issue to implement a long-term plan like the Kigali Water Supply M/P, utilizing a coordination mechanism among development partners has been examined in the Study to enhance JICA as well as other international partners to participate actively. Rwandan side has already has the mechanism among international partners in the water sector.

(9) Priority Project

Three projects were identified as urgent projects in 15-Year Investment Plan: NRW Reduction for Notra-Remera Area, Construction of Masaka Water Supply System and Expansion of Karengwe Water Supply System. The preparatory survey for the project of NRW Reduction for Notra-Remera Area, which formulates Japan's Grant Aid project, started in October 2021. The feasibility studies are conducted for the other projects in this M/P Project.

(10) Recommendation

10 recommendations are summarized in three pillars on a foundation which supports the vision of the utility (**Figure 7**).

The following aspects can be regarded as a foundation to ensure firm implementation of the M/P and 15-YIP:

- No. 1 is for establishment of new cross-organizational teams called One Strategic Team (OST) within WASAC and Program Supporting Committee (PC) having participation from the various organizations including concerned ministries and regional government, which is to monitor progress of M/P and 15-YIP.
- No. 2 is for implementation of organizational strengthening measures having cooperation of development partners for the sake of realizing/facilitating the M/P and 15-YIP.

Then, the following three pillars are standing at the above firm foundation:

- No. 3 and 4 itemize measures for accelerating

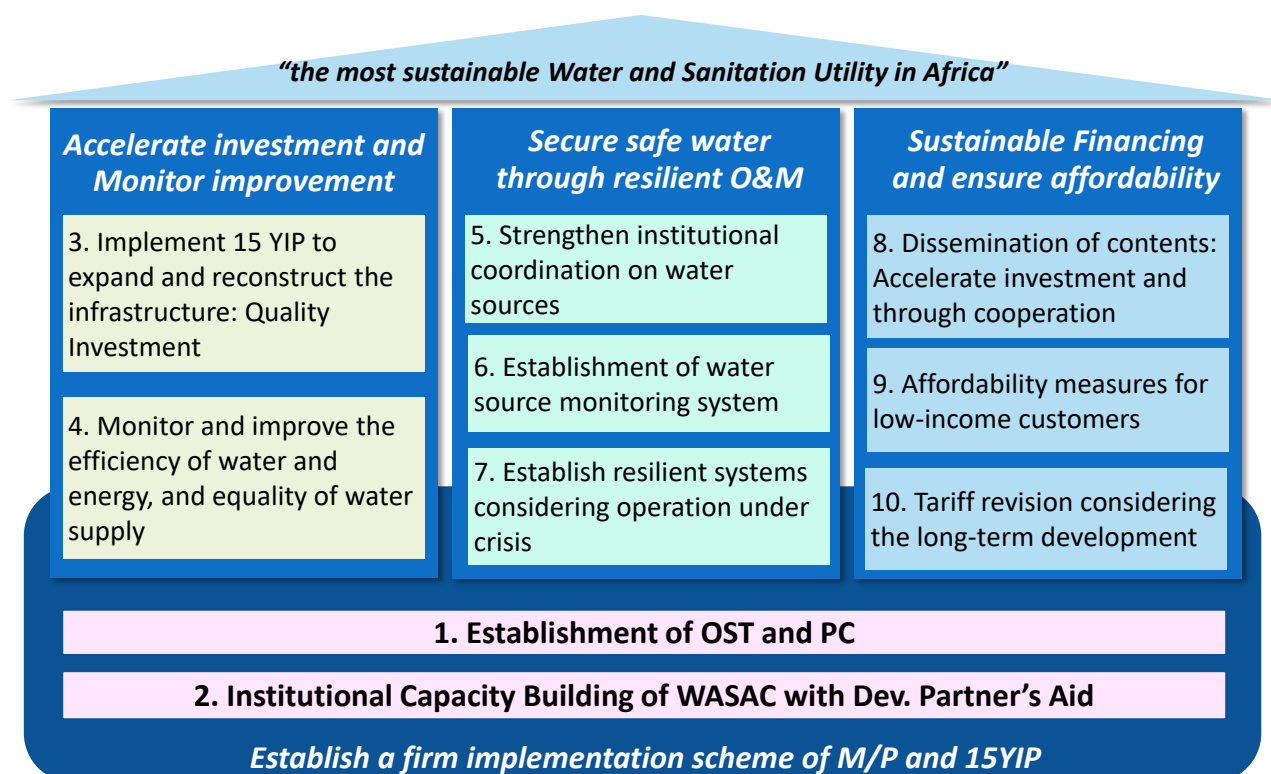


Figure 7 Recommendations

investment for the candidate projects listed in the

M/P and 15-YIP and monitoring the effect brought by the projects.

- No.5, 6, and 7 itemize measures for securing safe water through proper operation and maintenance of water supply facilities.
- No. 8, 9, and 10 itemize the measures for ensuring sustainable financial source for future development, giving considerations in low-income groups.

The above three pillars will support the vision of WASAC.

3.2. Feasibility Study (F/S) for the Project for Expansion of Karengere Water Supply System

(1) Background

Water demand in the eastern part of Kigali is dramatically increasing. Capacity of the existing Karengere WTP to supply water to the study area is overloaded (15,000 m³/day) compared to its design capacity (12,000 m³/day). Existing Facilities need a rehabilitation especially for the raw water pumping station because of the flooding. The intake pumps are damaged, overloaded, and vulnerable to the flooding risk. The old raw water intake pipe is damaged and not working properly.

This Project is one of the most urgent components of the Kigali Water Supply M/P to serve essential water to the people living in the east in the City of Kigali and Rwamagana District. The Project intends to expand the existing Karengere WTP sourcing water from Lake Mugesera from a capacity of 12,000 m³/day to 48,000 m³/day in Phase 1 and will further expand it to 120,000 m³/day in Phase 2.

The required land for the expansion of the WTP is illustrated in **Figure 8**. The proposed land for the WTP is located next to the existing Karengere WTP site. The proposed land for the Intake is also close to the existing Intake Pumping Station.

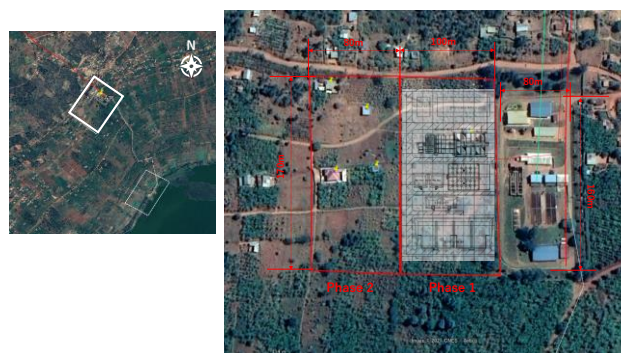


Figure 8 Existing Karengere WTP and required land

(2) Water Supply Area

Water Supply Area of existing Karengere WTP includes Ndera, Rusororo, Kanombe, Nyarugunga, and Masaka sectors in the City of Kigali and some part of Muyumbu and Nyakaliro sectors in Rwamagana district. The target year for the completion of the WTPs and major water transmission systems is 2026, and the population in the target area is then 405,000.

(3) Treatment Process

Water quality data of treated water at existing Karengere WTP in 2018 has been collected and studied, which indicated that the treated water quality of the existing Karengere WTP could comply with Rwanda drinking water quality standards by conventional treatment process. Based on careful evaluation as well as the treatment performance of the existing unit treatment process, the best suited treatment process for the WTP for the F/S is proposed.

(4) Transmission and Distribution System

Transmission routes and location of nodes for the hydraulic calculation are indicated as in **Figure 9**.

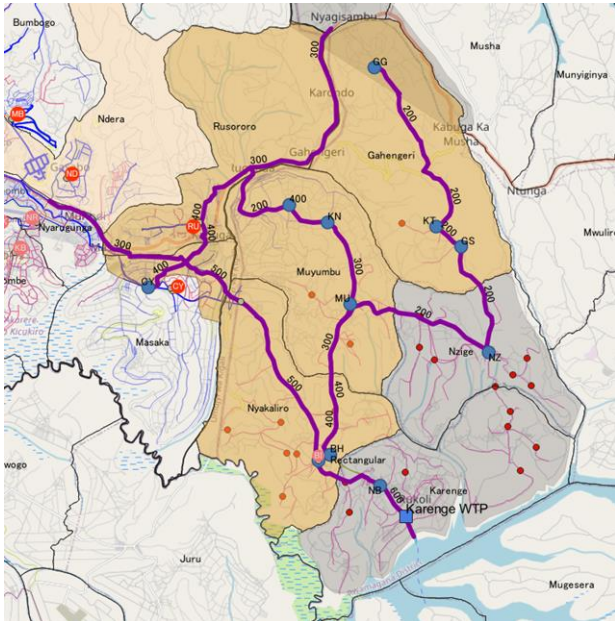
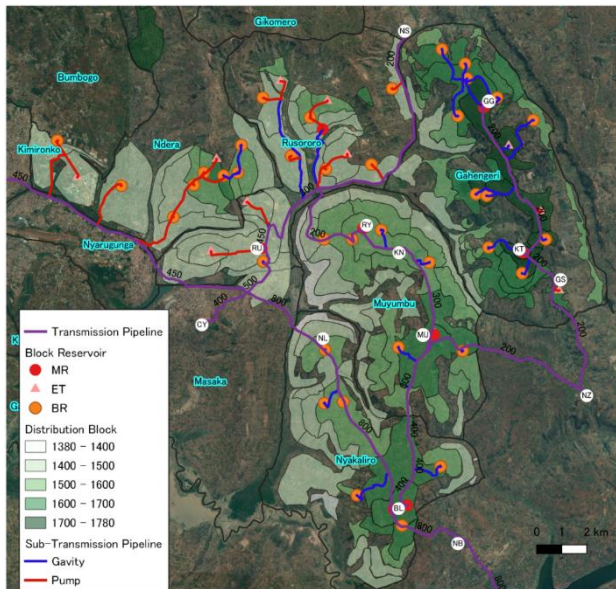


Figure 9 Water Transmission Models

One of the geographic features of the city is large elevation gap, which makes it difficult to implement control water supply pressure adequately. To tackle these issues, we propose to separate the water supply area hydraulically into several distribution blocks as shown in **Figure 10**.



**Figure 10 Distribution Block System
(Block, Reservoir, Pipelines)**

(5) Conclusion

- The target water supply coverage by the Project is 100% after the completion, including piped water connections and the public tap.

- The total target population as beneficiaries is approximately 493,500 populations in the year 2030.
- The schedule showed that the water supply could be inaugurated from the end of the Year 2026 if all procedures go smoothly.
- Preliminary Environmental Impact Assessment shows that the impact from the Project was very limited.
- The Karege Project is feasible in terms of technical aspects, economic and financial aspects and environmental and social aspects.

3.3. Feasibility Study for the Project for Construction of Masaka Water Supply System

(1) Background

This Project for Construction of Masaka Water Treatment Plant was selected as a priority project in the Kigali Water Supply Masterplan (KWSMP), as one of the most urgent components of the water supply expansion to serve essential water to the people, especially those living in the growing east in City of Kigali. The Project intends to construct a new WTP sourcing groundwater along Akagera River with a capacity of 20,000 m³/day (Phase 1) and 40,000 m³/day (Phase 2). The Project is urgent because the water demand is high and growing rapidly in the service area.

(2) Water Supply Area

Water Supply Area for new Masaka WTP and the existing water supply systems includes entire Masaka sector which is geographically separated from the adjacent sectors. The existing water consumption is estimated to be approximately 4,300 m³/day. The total daily average water demand will reach 10,700 m³/day in the year 2030, and 18,700 in the year 2035. The demand will then be doubled to 40,000 m³/day in the year 2042 and will reach 195,100 m³/day in the year 2050

ultimately.

(3) Treatment Process

It is recommended to use water from boreholes as being done in Kanzenze WTP in order to avoid high turbidity and to avoid the risk of possible contamination of the river water. Core drilling and water well drilling were carried out to study the aquifer property at flood plain of Akagera River around Masaka area. The result suggests that the number of wells for the Masaka WTP will be 15. The respective production capacity is planned as 1,600 m³/day/borehole (**Figure 11**). Total well production will be 24,000 m³/day (15 boreholes x 1,600 m³/day/borehole).

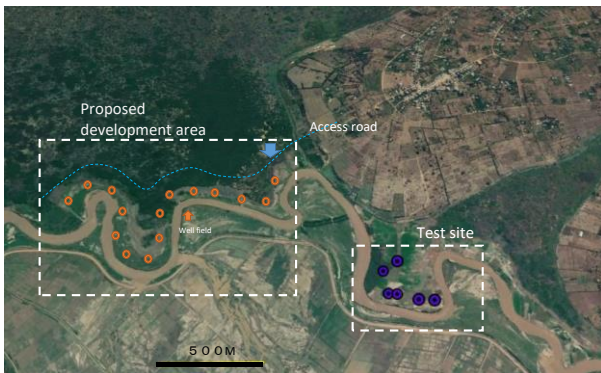


Figure 11 Proposed Wellfield Site and Test Site

Based on the treatment performance in the existing Nzove 1 WTP and Kanzenze WTP where has similar issues of raw water quality such as turbidity, ammonia, bacteria, iron and manganese, treatment process for the WTP is proposed.



Photo: Production Well for Pumping Tests

(4) Transmission and Distribution System

The main transmission system for the Masaka WTP is the route to the Cyimo reservoirs. Considering the current and future distribution systems, water demand in the middle-lower elevation areas is high. Considering minimizing energy cost, transmission system which shows figure below (**Figure 12**) was adopted for this study.

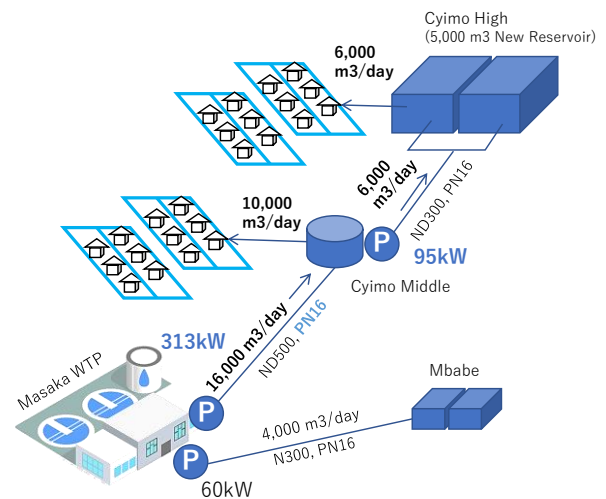


Figure 12 Adopted Transmission System and its Hydraulics

10 distribution blocks are identified in the water supply area. The schematic location of the reservoirs is illustrated in **Figure 13**.

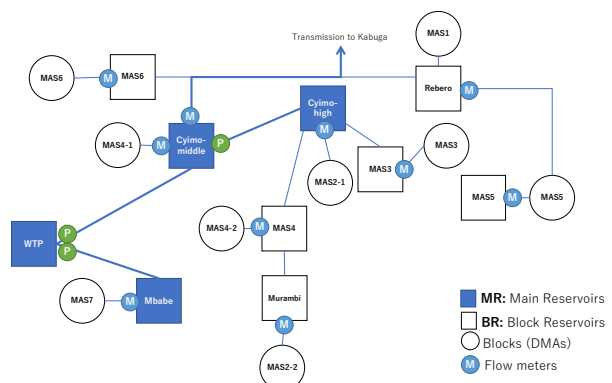


Figure 13 Distribution Reservoirs Systems

(5) Conclusion

- The target water supply coverage by the Project is 100% after the completion.

- The scope of work includes the intake expansion, WTP, water transmission and distribution systems.
- The WTP assumed high-rate filtration to treat iron & manganese, coagulation and rapid sand filtration system.
- The total target population as beneficiaries is approximately 169,000 populations in the year 2035, which means an additional 143,000 will gain access to water by the project.
- The schedule showed that the water supply could be inaugurated from the end of the year 2026 if all procedures go smoothly.
- Preliminary Environmental Impact Assessment shows that the impact from the Project was very limited.
- The Masaka Project is feasible in terms of technical aspects, economic and financial aspects and environmental and social aspects.

number of WASAC staff participating working team meetings is more than 200 persons.



Photo: Activity of Working Team

4. Special Considerations and Lessons Learned

4.1. Setting Up of Working Team

The M/P has been prepared through collaborative work by the members of WASAC and the project team, creating working teams according to the field of expertise as shown in **Table 1** to increase WASAC's planning skill.

Table 1 List of Working Team

1	PM Team	Planning Management
2	WRD Team	Water Resource Development
3	WTP Team	Water Treatment Plant
4	RTD Team	Reservoirs, Transmission/Distribution
5	ESC Team	Environment and Social Consideration
6	TSFI Team	Tariff System and Financial Improvement
7	OMHRD Team	Operation and Maintenance, Human Resource Development



WASAC and the project team had a frequent communication through the entire project. Total number of the meetings is more than 90 times. The cumulative

4.2. Emergency Support for COVID-19

The project team cooperated for JICA's emergency support, including the procurement of water treatment chemicals, formulation of Business Continuity Plan (BCP) and procurement of a water tanker.

(1) Provision of Water Treatment Chemicals

Due to the spread of the COVID-19, the financial situation of WASAC is affected, and the budget for the next procurement of reagents and chemicals in a span of 3 to 6 months was insufficient. Therefore, reagents and chemicals are being procured as emergency support.

(2) Procurement of Water Tanker

To meet the demand surge due to COVID-19, JICA Rwanda office procured water tanks especially in remote areas facing a shortage of water supply. The private water tankers delivered the water to the tanks instead of WASAC who has no water tanker. However, due to the budget limitation it cannot sustainably supply by private water tankers nor procure own water tanker. Therefore, with the requirement from WASAC, the project team procured a water tanker as part of the BCP formulation under the support of the project team. The water tanker is delivered to WASAC in September 2021.



Photo: Water Tank Truck

The project team proposed the operation plan of the water tank truck and carried out the workshop to explain it to WASAC. The project team supported and monitored the operation for 1 month after the water tank truck was in operation.

(3) The Business Continuity Plan

The Business Continuity Plan (BCP) was developed to mitigate the influence of COVID-19 causing significant impacts to the business continuity as well as to lower the peak and recover to the normal operation level within a certain timeframe without interrupting prioritized functions during the event (**Figure 14**).

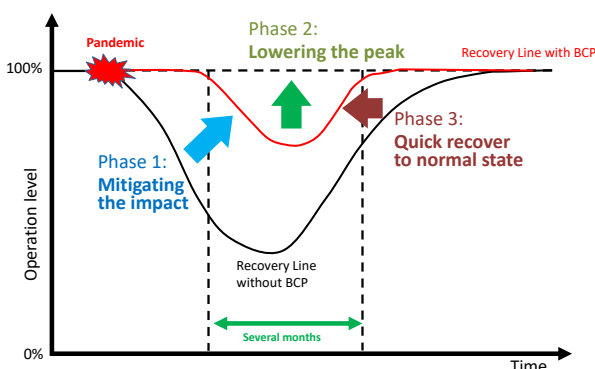


Figure 14 Concept of BCP

The lessons learned from the experience of COVID-19 were summarized based on the staff interviews and the survey conducted, focusing on their responses to the

emergency and the critical issues that were the bottleneck for business continuity. The financial impact to the utility was also studied. The BCP Task Force was established to enhance the collaboration of the project team and WASAC. The team is in charge of formulating, implementing, and updating the BCP as a coronavirus infectious disease control team.

4.3. Remote Work during COVID-19 Pandemic

When the project activities at Kigali were restricted due to the pandemic, the project team collaborated with WASAC remotely as much as possible. We continuously communicated through weekly online meetings.



Photo: Online Meeting with Counterpart

4.4. Communication with WASAC Executive

The project team shared the contents of the Study and the progress of the Kigali M/P formulation to WASAC Executive including CEO and Deputy CEO at every milestone to increase their understanding of the progress, consideration, and alternatives of the planning so that they can be effectively involved with the coordination of planning and policies related to development of water supply system in Rwanda. It has led to the opportunities to explain and discuss the contents of the M/P to the Ministers from the related ministries or to have a meeting with a donor who is interested in the results of one of the Feasibility Studies.



Photo: Meeting with Minister of MININFRA

4.5. Coordination with the related projects

The national master plan for water and wastewater by AfDB (AfDB M/P) contains 10-Year Investment Plan for water and wastewater in the whole nation except CoK whereas Kigali M/P contains 15-Year Investment Plan for water supply system in CoK. The project team had close communication with people involved with AfDB M/P and WASAC (e.g., participation to the workshop of the AfDB M/P and discussion with the consultants for this project) to ensure the consistency.

The Kigali City Master Plan (Kigali City M/P) was under the process of revising at the beginning of the Kigali Water Supply M/P Project. The project team had a close communication with CoK and the consultants who are involved with Kigali City M/P to clear the relationship between the two master plans including the confirmation of validity of the population forecast and the contents of the development plan. It resulted in establishment of the KWSMP consistent with Kigali City M/P.

(Project Period: From March 2019 to November 2021)